10th WORLD CONGRESS ON RAILWAY RESEARCH
25th - 27th Nov 2013 | Sydney Convention and Exhibition Centre, Australia

The role of rail in a transport system to limit the impact of global warming

26 November 2013

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Overview

CONTEXT

- Character of Australian transport
- Options for reducing emissions

METHOD

- Australian transport system
- Simulations

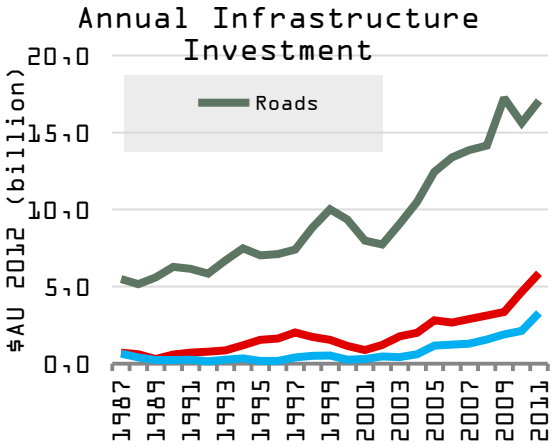
RESULTS

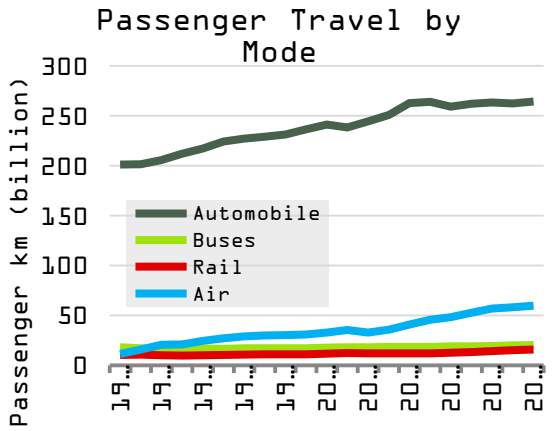
- Change in travel activity
- Potential for rail services

- Average **increase of 1.7% p.a.** despite improvements in technological efficiency

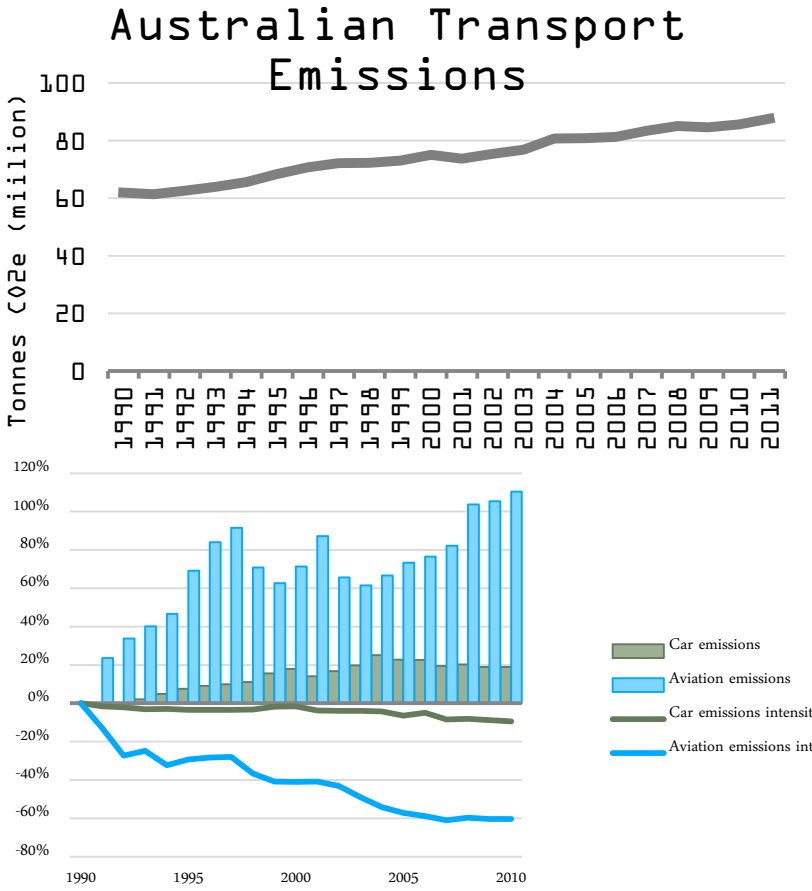
CONTEXT

Trend of transport emissions





[BITRE, 2012]



[National Greenhouse Gas Inventory, 2013]

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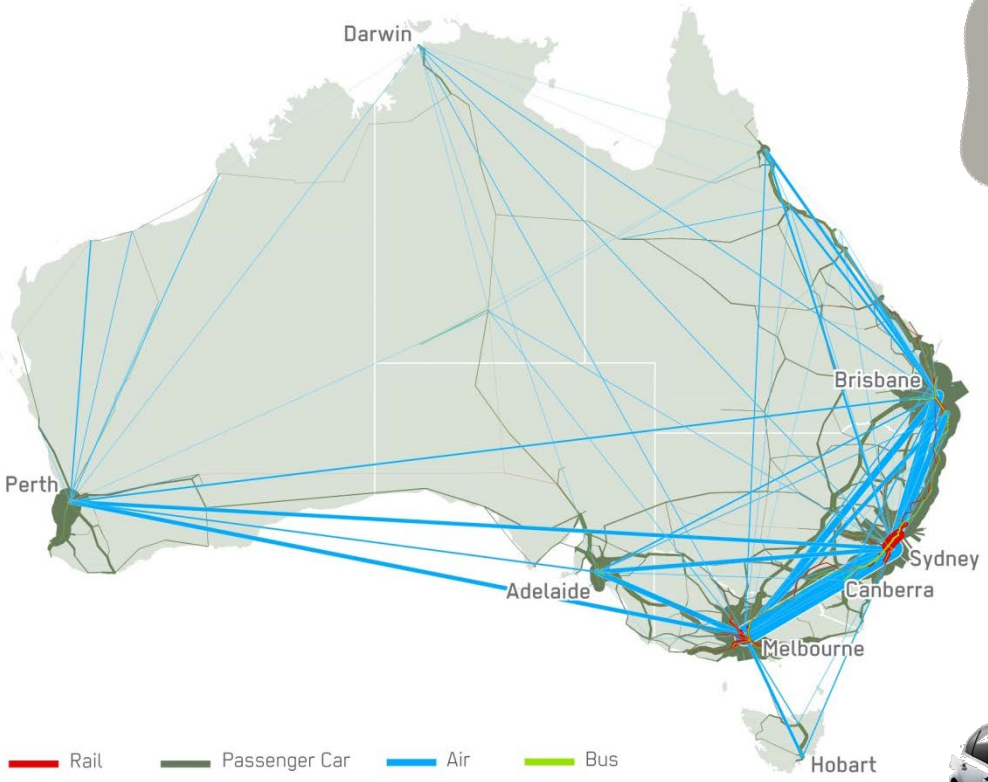
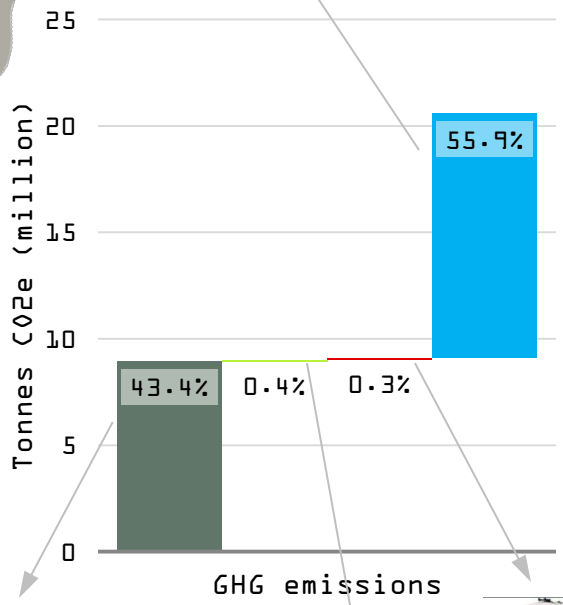
CONTEXT

Regional passenger travel



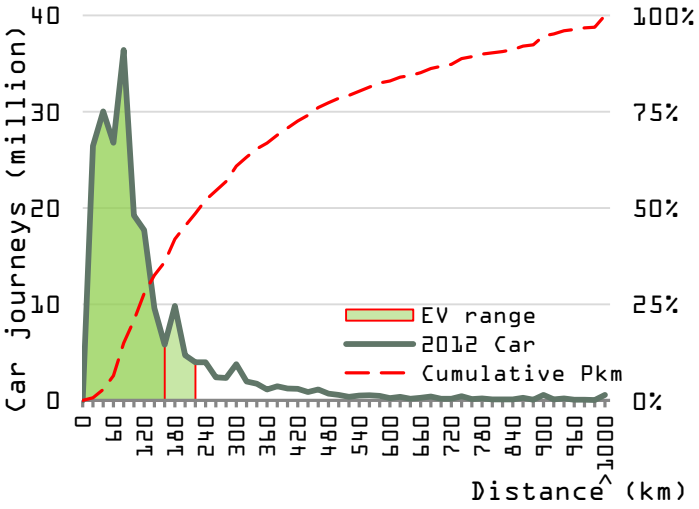


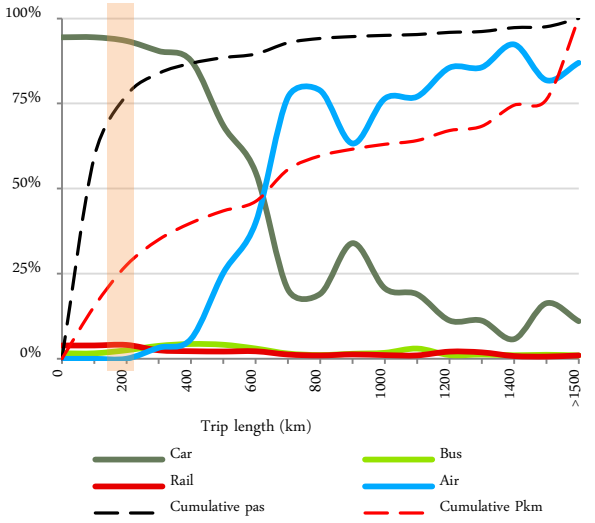
CONTEXT

Automobiles

Battery electric vehicle performance

- Battery range a limiting factor for regional travel
- Current range typically 160km, modeled to increase to 220km
- Range covers **86%** of all current car journeys but only **49%** of Pkm
- **Recharging becomes a considerable time burden beyond this point**
  (20kW 'fast charging' rates applied in model)





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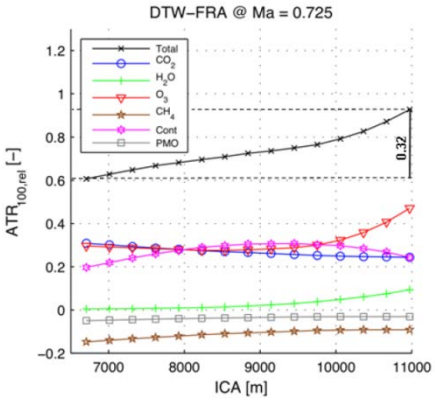
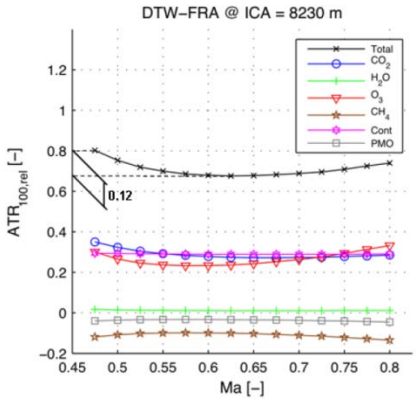
CONTEXT

CATS

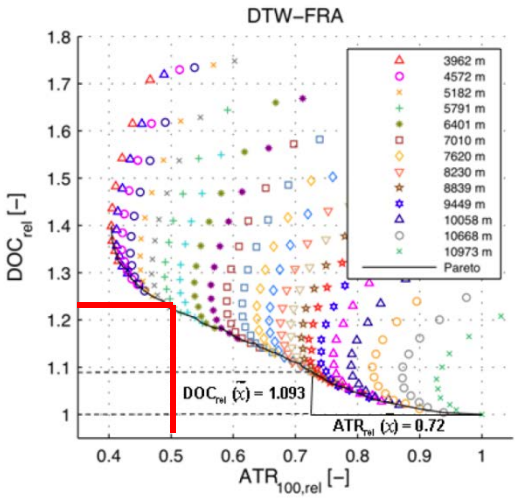




Aircraft

Climate compatible Air Transport System (CATS)

- Combustion emissions at cruise altitude have **double the warming impact** as at sea level
- Response to change in altitude and cruise speed have been simulated [Koch, A., et al., 2011]
- Optimised conditions indicate **>50% reductions** to Atmospheric Temperature Response (ATR)
- Position modeled corresponding to 50% reduction (red), eliminating the multiplier effect
- This results in a **22% increase in Direct Operating Cost** (DOC) and a cruise speed of Ma=0.52 which increases travel times



[Figures from Koch, A., et al., 2011]

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METHOD

Development of a transport simulation model

Network model

- Regional transport network model created for all modes
- Necessary for determination of travel time, distance and accomplishment of assignments
- Focus on trunk routes, because only long-distance traffic will be calculated
- 49 300 km road
- 88 flight routes
- 15 700 km rail
- Population: 17.8 Mio inhabitants included in the model

METHOD

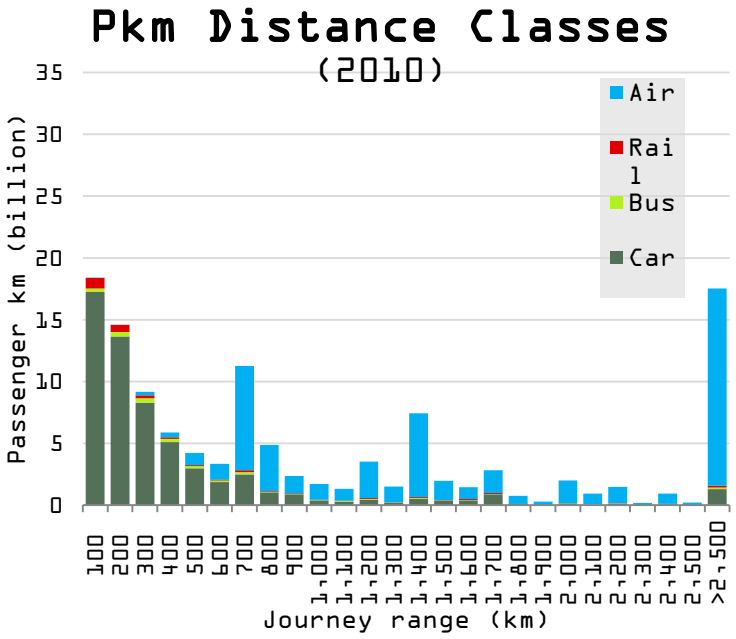
Development of a transport simulation model

Traffic data

- Data about national traffic gathered from National Census for commuter data and National and International Visitor Survey 2009-11 for business and other purposes

Forecast of population, economy and price data

- Population will grow to 28.1 Mio in 2030, 90% of them will live in urban areas
- Sydney and Melbourne both will have almost 5 Mio inhabitants
- Increase of GDP per capita during the forecast period
- Moderate increase of fuel price

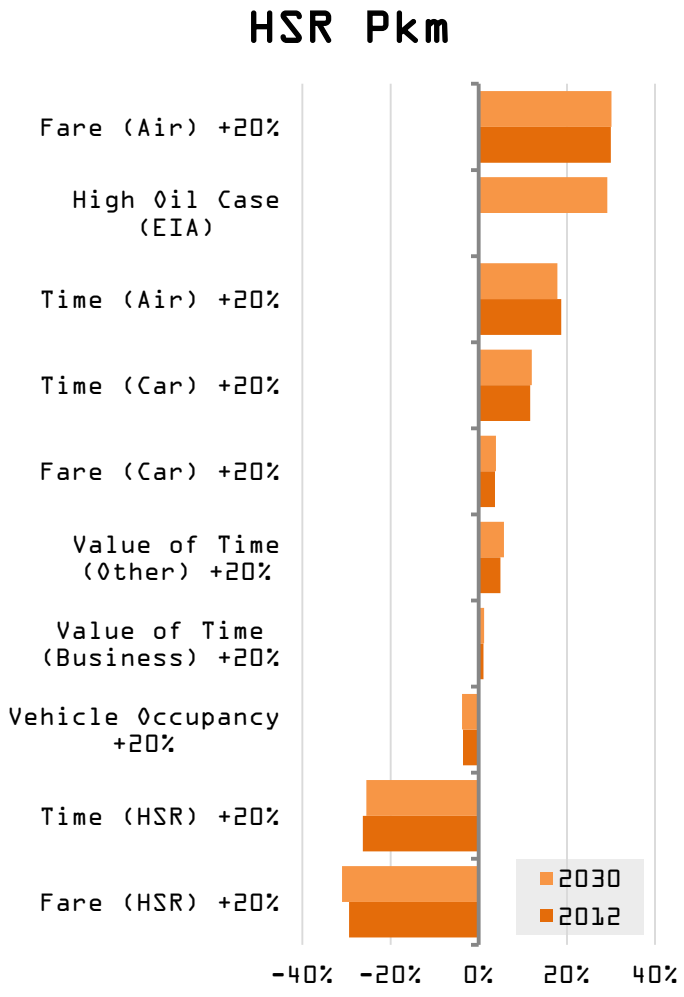


METHOD

Development of a transport simulation model

Modal split analysis

- Approach with Generalized Cost (GC), which consists of Real price and Time Cost
- Value of Time (VoT):
  - 3-4 times higher for Business travel (60 – 80 $/hour)
  - Higher for car, lower for rail and HSR (time can be used)
- Use of multinomial logit model



METHOD

Development of a transport simulation model

Trip generation and distribution

- Using modified gravity model of the Australian Bureau of Infrastructure, Transport and Regional Economics [BITRE, 2009]
- 31% of relations (OD pairs) of the NVS data included, but 84% of journeys

$$T_{ij} = A_{ij} \frac{(P_i * P_j * 2Y)^{\alpha}}{(C_{ij})^{\beta}}$$

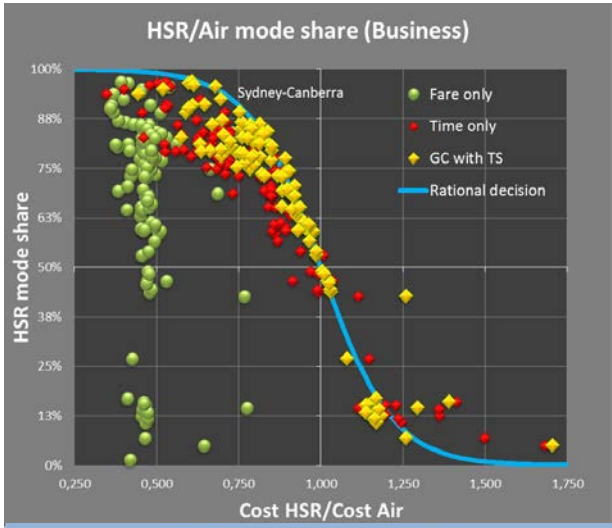
Relation	2010 Pax (million)	2030 Pax with HSR (million)	Increase	2030 HSR share (of all)	2010 GC Air Business	2030 GC Air Business	2030 GC HSR Business
Melbourne – Sydney	7.8	14.1	+ 81%	58 %	$ 697	$ 751	$ 527
Sydney – Brisbane	4.1	7.7	+ 88 %	62 %	$ 712	$ 767	$537
Sydney - Canberra	4.2	6.8	+ 62%	32 %	$ 483	$ 530	$ 207
Melbourne - Brisbane	2.2	3.5	+ 59%	8 %	$ 905	$ 969	$ 955

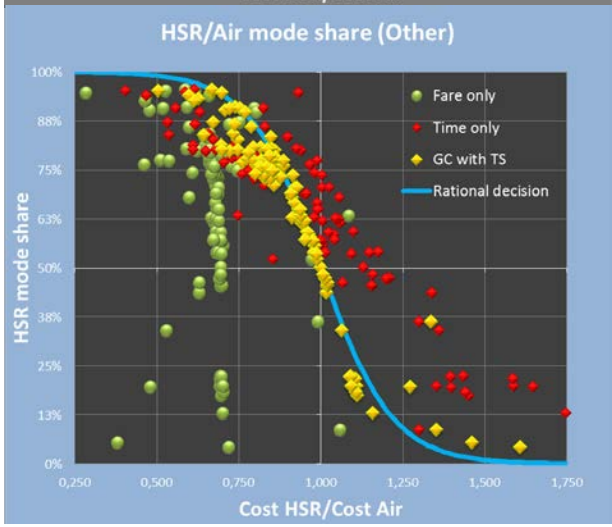
METHOD

High Speed System for Australia

Mode share: High Speed Rail / Air

- Calibration of HSR not possible, because mode doesn't exist yet
- Approach with comparison of Generalized Cost for HSR and Air
- Blue graph indicates a "rational decision", evidence with time-based analysis from Europe [Jorritsma, 2009]
- Fare only (green): poor results, time plays a significant role for mode choice
- Time only (red): demand overstated for Other purposes
- Generalized Cost with Time Sensitivity: good matching of results with blue curve



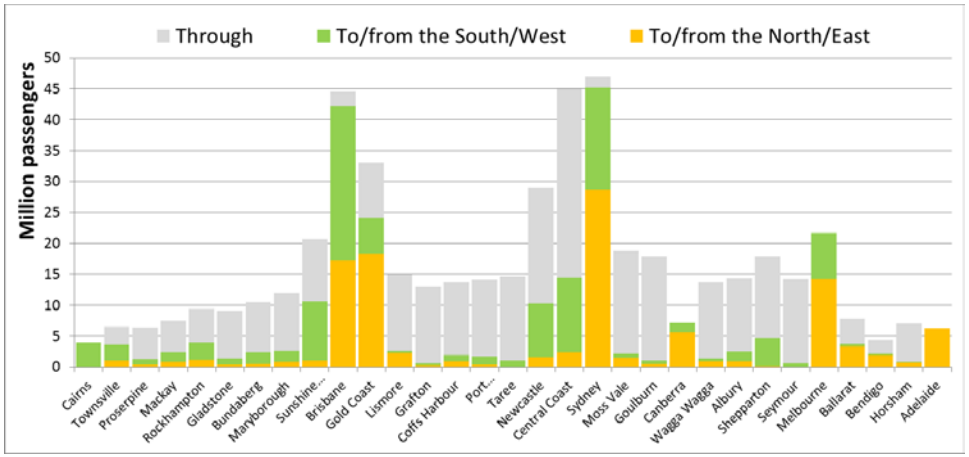


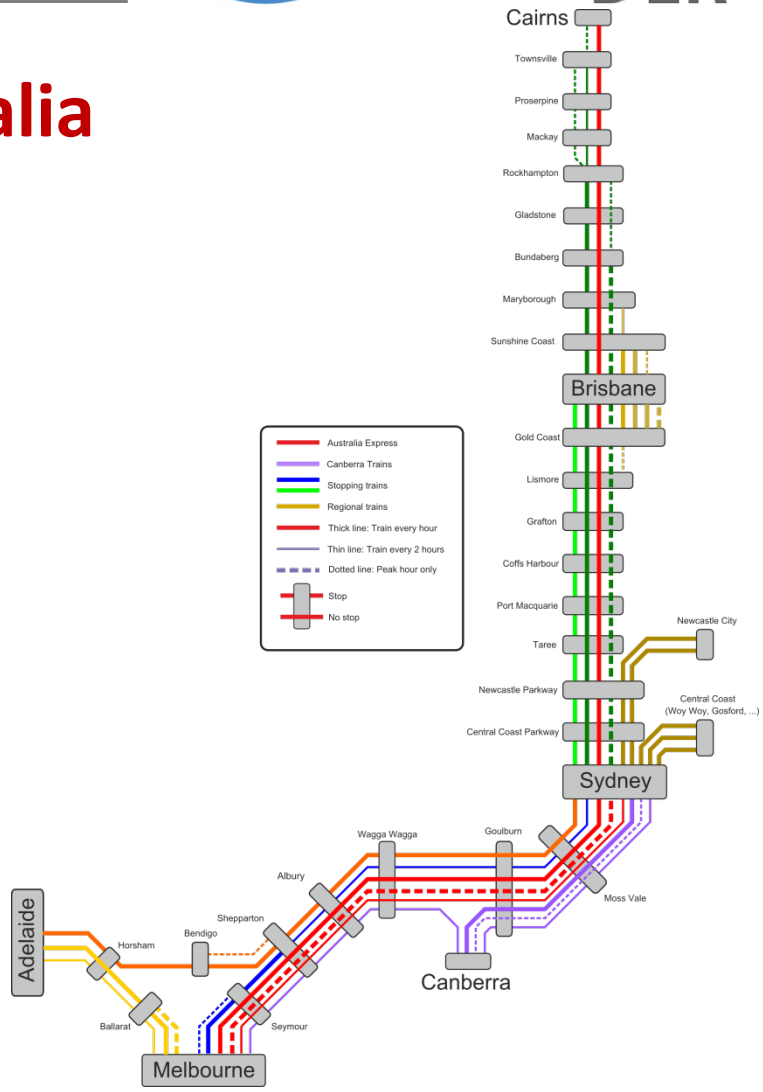
METHOD

High Speed System for Australia

Operational concept

- Development of train routes with minimized changing necessity and maximized average speed
- But: at least one train/hour everywhere
- Special regional high speed services to Central Coast, Newcastle and Gold Coast

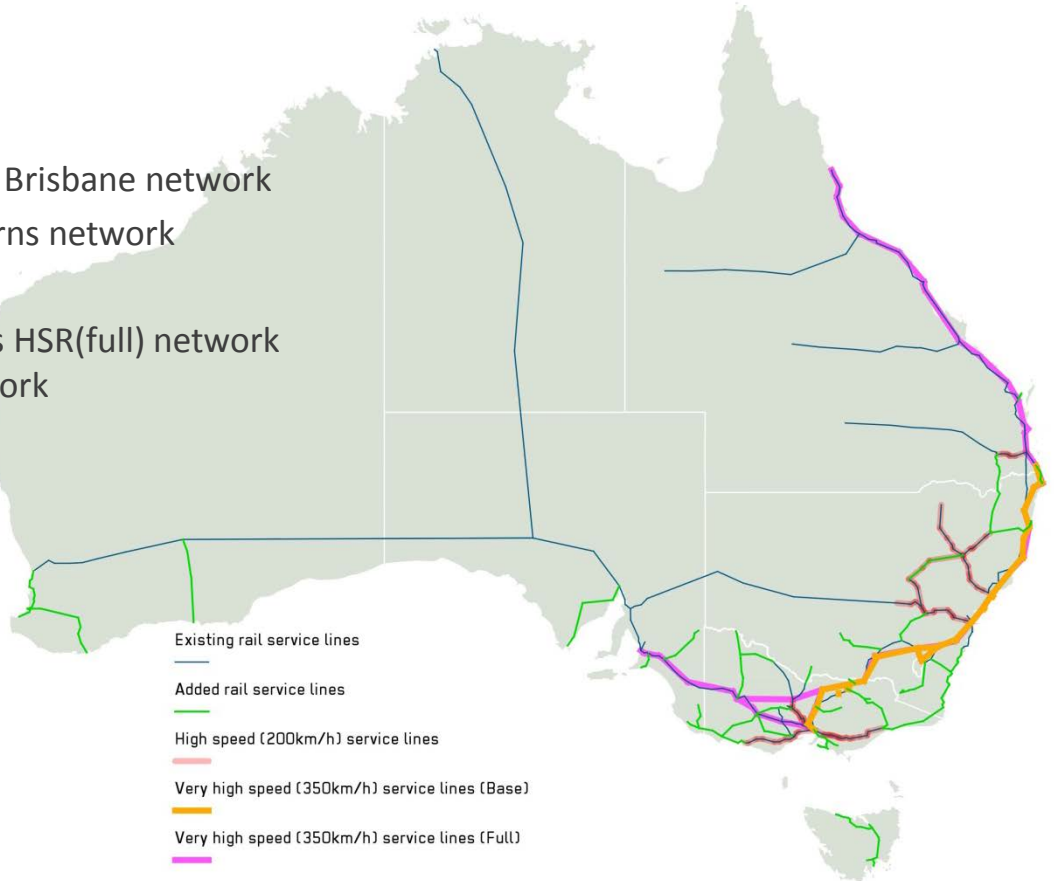




METHOD

Scenarios modelled

1. **2012 BAU** – baseline
2. **2030 BAU** – projection
3. **2030 HSR(base)** – Melbourne to Brisbane network
4. **2030 HSR(full)** – Adelaide to Cairns network
5. **2030 EV & CATS** – no HSR
6. **2030 EV & CATS + Rail** – includes HSR(full) network and upgrades of classic rail network



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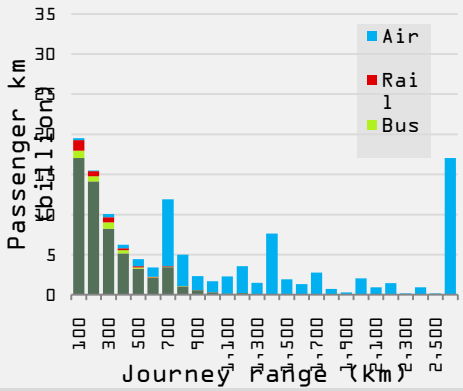
RESULTS

Scenarios

1 2012 Baseline

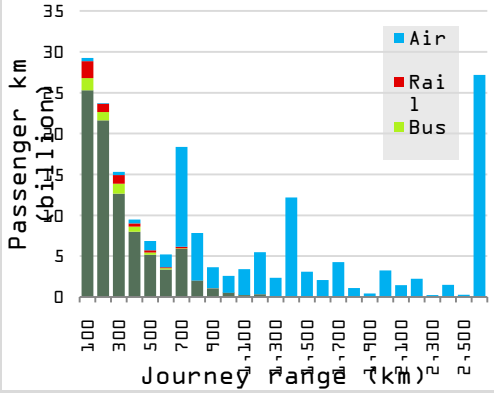
- PAX: 489 million
- Pkm: 127 billion
- **CO2e 20.5 MT**



2 2030 BAU

- PAX: 720 million
- Pkm: 192 billion
- **CO2e 31.6 MT**

51.1% Pkm increase

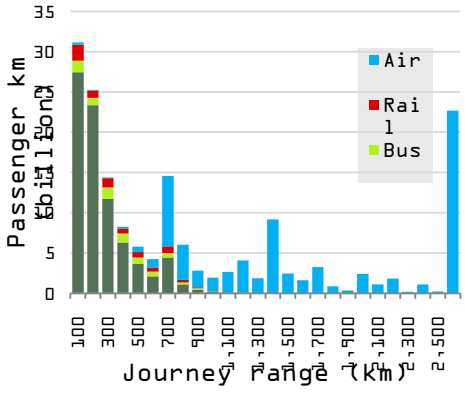


5 2030 EV + CATS

- PAX: 729 million
- Pkm: 170 billion
- **CO2e 0.3 MT**

(7.1 MT without aviation biofuel)

33.8% Pkm increase

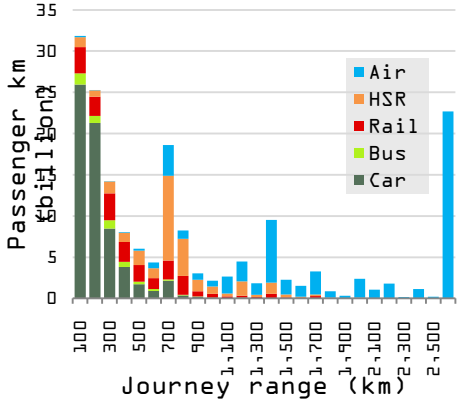


6 2030 EV + CATS + Rail

- PAX: 744 million
- Pkm: 178 billion
- **CO2e 0.1 MT**

(5.3 MT without aviation biofuel)

40.2% Pkm increase



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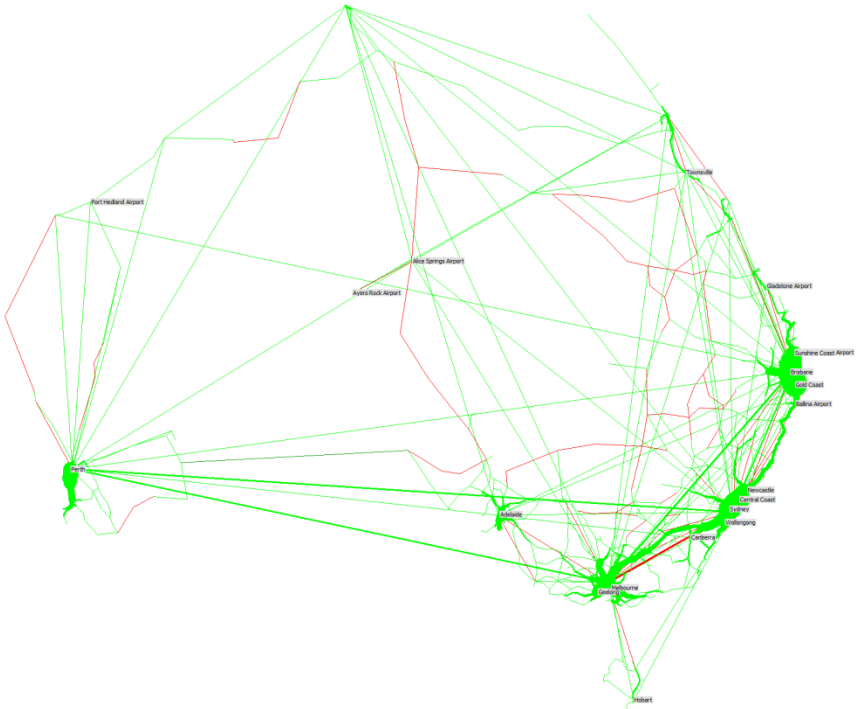
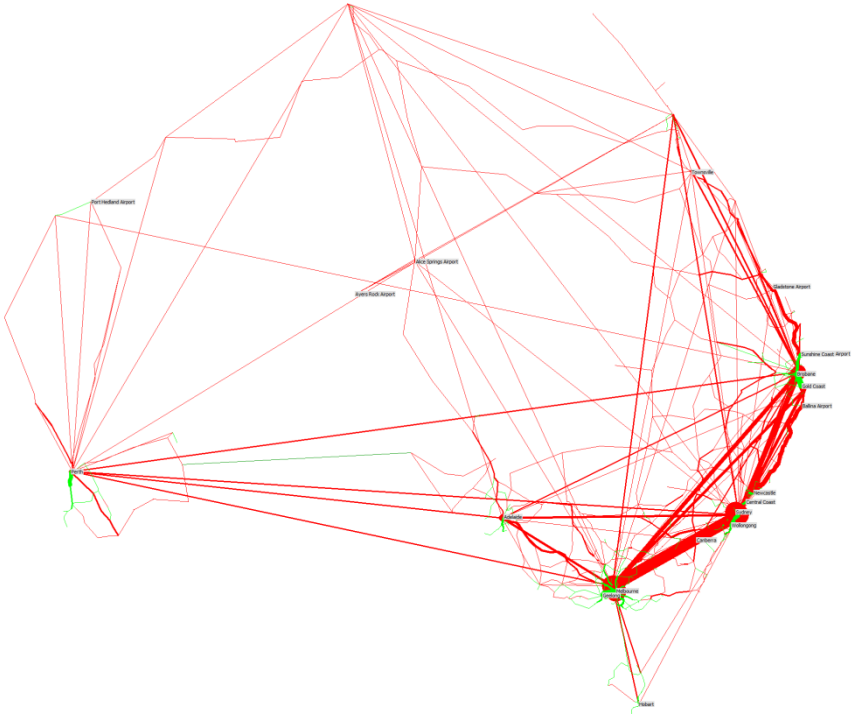
RESULTS

Change in travel activity



- Change in Air and Car travel from **2012 Baseline to Scenario 5**



- Change in Air and Car travel from **2030 BAU to Scenario 5**

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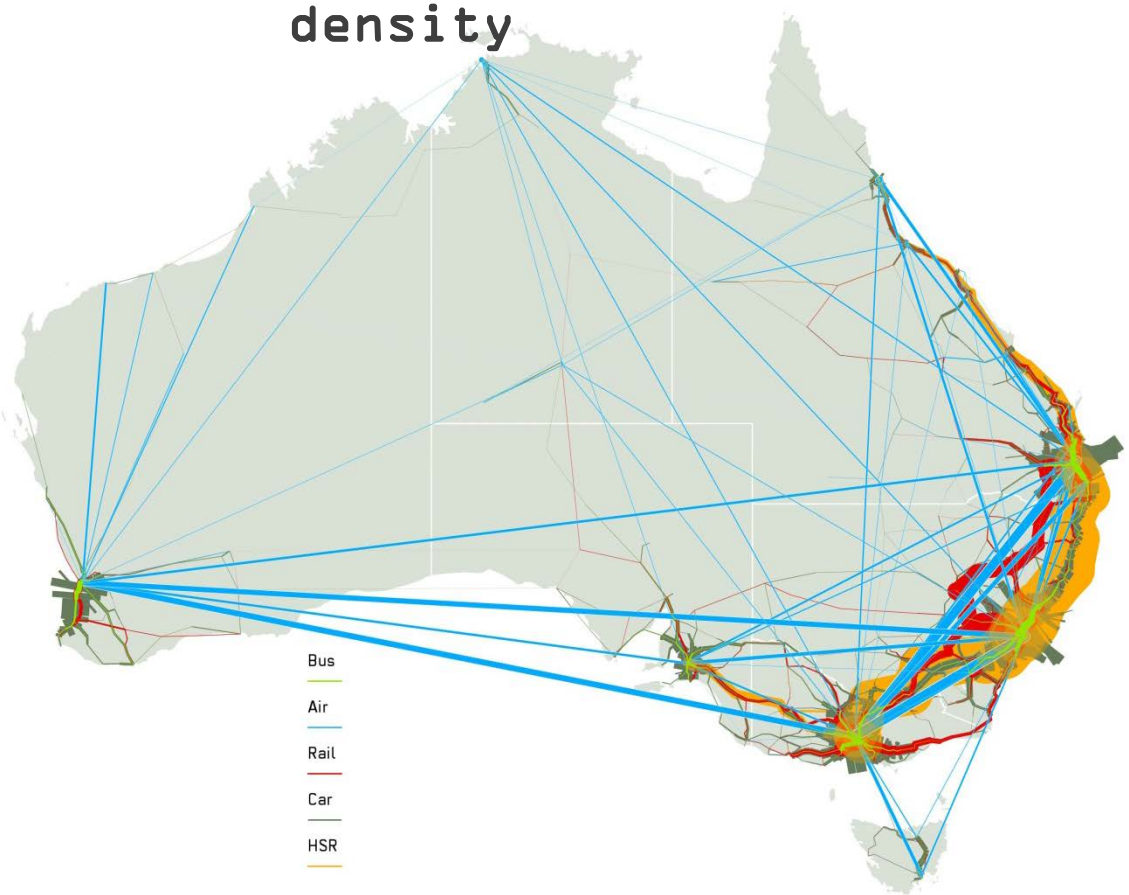
RESULTS

Rail system potential

Modal passenger density



Scenario 6

2030 EV + CATS + Rail

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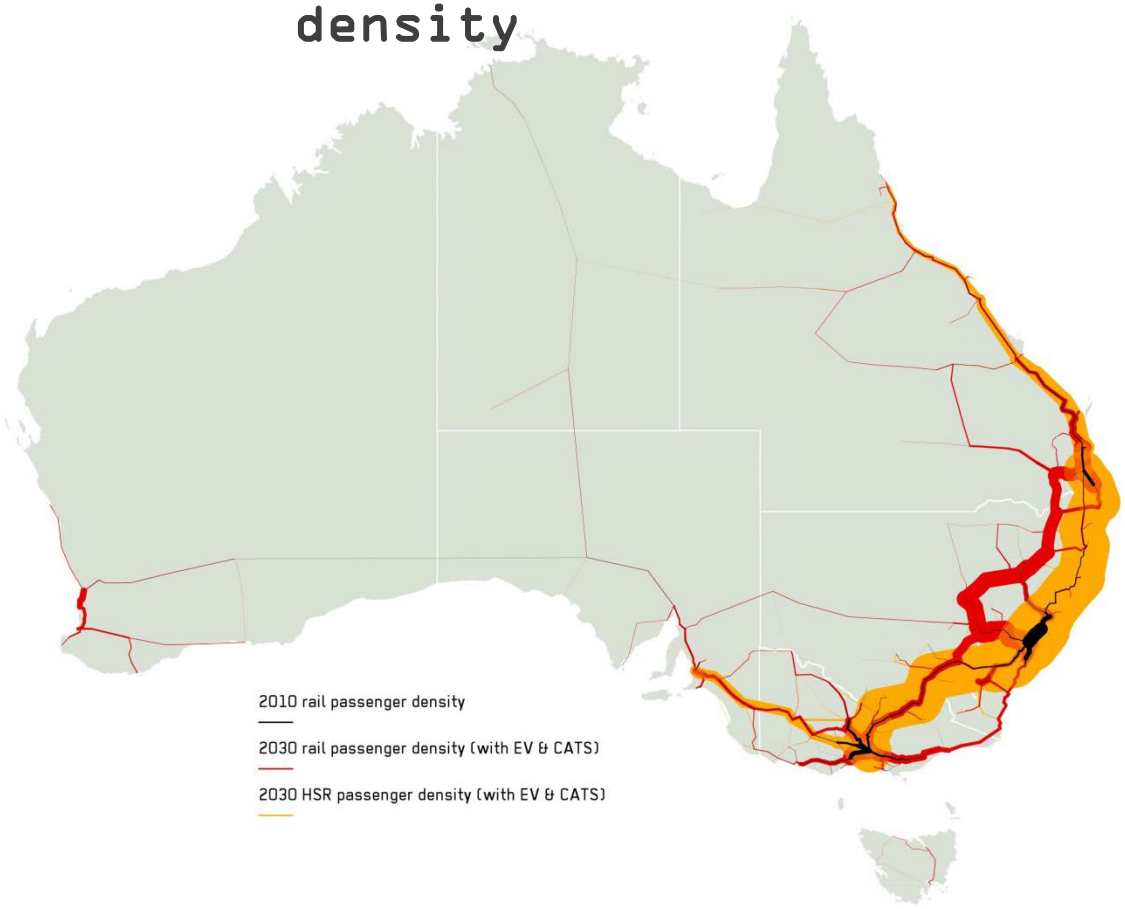
RESULTS

Rail system potential

Rail passenger density



Scenario 6

2030 EV + CATS + Rail

Conclusions

- Continuing trend will lead to increasing emissions
- Solutions are available to make significant reductions
- Taking measures to reduce emissions of existing transport system will increase travel friction across regional Australia
- Investment in rail will reduce this travel friction
- Demographic development and topography justify HSR in the southeast of Australia

References

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- *National Greenhouse Gas Inventory*, Available from: http://ageis.climatechange.gov.au/, [accessed: 29 June 2013].
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- Jorritsma P., *Substitution Opportunities of High Speed Train for Air Transport*, 2009, Aerlines Magazine, [accessed: 2 November 2012]; Available from: http://aerlinesmagazine.wordpress.com/2009/05/01/substitution-opportunities-of-high-speed-train-for-air-transport/.